ART. XVI.—*Notes on the Meteorology of the Australian Alps.*

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IN an interesting report on the physical character and resources of Gippsland, by Mr. Skene, Surveyor-General, and Mr. R. B. Smyth, late Secretary for Mines, the following remarks concerning the meteorology of Gippsland are made:—

"It is much to be regretted that so little is known of the meteorology of Gippsland. A few observations have been made at one or more points on the coast, but no information is obtainable respecting the climate of that part of Gippsland bordering on the Dividing Range. In that area there are rich soils, much of the land is well grassed, and the enclosures which we saw under cultivation presented the most favourable aspects, and it is not creditable to the colony that vague and probably incorrect statements respecting the fall of rain, the temperature, and the occurrence of snowstorms cannot be met by an appeal to accurate records of the weather. It is our duty to recommend that no time be lost in instituting a series of meteorological observations in Gippsland; able and willing observers can be found in all towns and settlements, and with a little zeal at the seat of Government the work would proceed rapidly, and many of the representations which might deter settlers from occupying the higher lands would, we are convinced, be proved to be untrustworthy or exaggerated."

Acting on the suggestions embodied in the foregoing, and with a view to obtain some reliable data to aid physiographic researches in the Australian Alps, I commenced, during 1879, recording weather observations at Omeo, and, by a correspondence with some of the oldest settlers and other inhabitants, to elicit information respecting the weather during previous years. So far the results seem to confirm the suggestions made in the above-mentioned report; for an appeal to the records of the past five years would certainly indicate that the empirical representations as to the extreme severity of the climate are not altogether to be relied on, unless we assume, as some of the old residents still assert, the climate has undergone considerable modification during the period herein discussed. I have elsewhere* drawn attention to the excellent yields of cereals on the Omeo Plains during the past seven years, as disproving the notions of the early pastoral settlers, that it would only be an exceptional season in which wheat could be grown at these sub-Alpine elevations, viz., between 2500 and 3000 feet, owing, it was said, to late frosts, snow, and other unsuitable climatic conditions. The adaptability of various portions of the Australian Alps for most, if not all, the extra-tropical European, Asiatic, and North American vegetable products, is now being proved by the influx of settlers under the provisions of the Land Act 1869. Many localities between 3000 and 4000 feet—such as the Benambra Creek uplands, referred to in previous paper to the Royal Society,† have been selected and in occupation of resident farmers for some time. As an instance of what may be cultivated during summer even at higher levels, it may be interesting to note that cabbage, green peas, and other like culinary esculents are grown every season—January and February—at Dargo High Plains (4800 to 5000 feet above sea-level). The rapid growth of vegetation during mid-summer is a noticeable feature characteristic of these highlands, especially in those localities where rich volcanic soils are disintegrated from the tertiary basalts. As a summer sanatorium these highlands should become valuable. Even to one accustomed to mountain climbing, to cool pure air, and lovely scenery, the extreme grandeur and sublimity of the landscape, the freshness, rarity, and etherial purity of the air on our highest peaks and table-lands, has a most exhilarating and invigorating influence. The importance of meteorological observations from the highest elevations over South-east Australia can, I think, hardly be over-estimated, from the fact that there is probably no other country where the necessary conditions for studying weather phenomena are more favourable. Surrounded by oceanic expanses, and with just sufficient vertical relief to cause obstruction to wind and water circulation, the higher regions of Australia offer a splendid area for investigating many interesting meteorological changes.

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* Notes on a Geological Sketch, Section Australian Alps. Trans. Royal Soc., S.A., 1884.

† Physical Features of Australian Alps. Trans. Royal Soc, Vict., p. 188.

The movements of circo-filum[*] in advance of cyclonic disturbances, could be observed with greater clearness from the Alpine stations free from the influence of smoke and other obstructions incidental to large cities in the lowlands. The causes which predominate in the deflection of extensive aërial currents, and the consequent condensation and precipitation of rain, snow, &c., over the Alps—whether such be due to ascensional movements of moisture-laden air;[†] to other thermal influence; or to the complex actions arising from the irregular barometric depressions and anti-cyclones which are constantly moving over the earth's surface in the temperate zones;[‡] the protrusions of areas of high and low pressures, &c.,[§] or other causes of like nature—would doubtless be more satisfactorily determined by establishing a chain of high-level observatories from the Western Australian ranges, across South Australia and the summits of the Australian Alps, to the Blue Mountains in New South Wales, and which might be expected to furnish data of sufficient scientific importance to enable our able Australian astronomers to establish some valuable weather laws, or, in addition to determining more fully the laws of meteorology prevailing over our Australian continent, enable them to reduce the already formulated theories of Europe and America to general laws, and, to quote the immortal Von Humboldt, "by a combination of thought and observation discern the constancy of phenomena in the midst of apparent change." The following statistics, relative to weather observations at Omeo, with notes on the higher regions surrounding this centre, are now given:—

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[*] Rev. Clement Lay, Q. J. of Met. Soc., Vol. IX., 1883.

[†] Rainfall of Cherrapunji, Q. J. of M. S., Vol. VII., 1882.

[‡] Scott's Meteorology, p. 332.

[§] President's Address, Vol. XVIII., p. 21, 1881, Trans. Ro. Soc. Vict.

RAINFALL.

TABLE *showing rainfall at Omeo for each month, the number of days upon which rain fell from June,* 1879, *to November,* 1884, *and the average per month for that period; by which it will be seen that October is the month of greatest mean rainfall and that January is the least, although the heaviest fall of rain during any single month occurred in February,* 1880, *and September,* 1883.

Year.	No. of Days.	January.	No. of Days.	February.	No. of Days.	March.	No. of Days.	April.	No. of Days.	May.	No. of Days.	June.	No. of Days.	July.	No. of Days.	August.	No. of Days.	September.	No. of Days.	October.	No. of Days.	November.	No. of Days.	December.	No. of Days during Year.	Totalforyear.
1879	..	..	..	..	..	..	..	..	..	..	..	1·39	10	1·76	8	1·70	15	2·60	10	4·26	9	2·59	8	1·31	..	..
1880	1	1·08	6	5·44	13	1·82	13	4·64	10	2·62	13	1·81	9	2·65	5	1·06	11	2·46	12	2·46	5	2·84	6	1·28	114	29·92
1881	5	0·86	4	2·24	7	3·42	3	1·17	5	1·09	9	1·49	7	0·41	9	1·84	11	1·53	10	2·81	12	3·52	8	1·60	90	21·98
1882	3	0·55	2	0·11	6	2·29	9	1·18	4	1·74	9	1·18	11	3·78	11	1·84	7	1·07	10	4·78	8	2·93	9	2·57	84	24·02
1883	5	0·91	6	1·73	5	0·85	5	1·18	11	1·41	5	1·43	10	1·48	7	1·73	13	5·02	14	2·47	8	1·44	9	1·17	98	20·82
1884	9	1·46	6	1·04	6	3·00	9	1·41	6	1·48	11	1·49	3	0·71	11	1·86	7	2·10	9	4·08	..	..	..	..	..	..
Mean	4·6	0·97	4·9	2·11	7·4	2·28	7·8	1·92	7·2	1·67	9·6	1·46	8·4	1·79	8·6	1·67	10·6	2·46	10·2	3·47	8·4	2·66	8	1·58	96	24·18

As the spring is fully three weeks later at Omeo, Omeo Plains, and the higher uplands at 3000-feet elevations, than on the lowlands up to 1000 feet, the October rains are generally most favourable to agricultural pursuits, and ensure seasonal regularity well adapted for cereal growths. The greatest fall of rain during 24 hours occurred on 28th February, 1880, when the gauge measured 3·38 inches, the wind blowing from S.W. That the amount of rainfall is greatest at the normal line of cloud flotation, approximately 3000 to 4000 feet in the Australian Alps, will be seen by comparing the records from those stations such as Grant, 4000 feet, in the Mitchell River, with those at Dargo, 1000 feet, in the same basin, only 14 miles distant. Thus during three or four years the average annual rainfall at Grant is probably 50 inches, at Dargo not more than 30 inches. Independently of the elevation, the situation of the station largely affects the precipitation of rain, which helps to increase the difference; for instance, the trend of the Dargo River valley from Dargo is southerly, and although partly exposed to the moisture-laden winds from the Pacific, it is nearly surrounded by high ranges. Grant, on the contrary, is on the crest of a high range fully exposed to the influence of south-westerly moisture-laden winds which sweep up the Dargo and Wongungarra Rivers, and to the north-western winds which are carried across the Dargo High Plains from the valley of the Ovens and tributaries. A station such as that which it is hoped may be established at Mount St. Bernard* would also show a proportionately large amount of snow or rainfall, as the ascensional movements of air from the valleys of the Ovens to the N.N.W., and the Wongungarra to the S.S.W., would doubtless be found to ensure a greater precipitation than other stations not so situated, although at a similar elevation of 5000 feet. The relation between winds and rainfall at Omeo is shown in the following table:—

Year.	North.	N.W.	N.E.	South.	S.W.	S.E.	E.	W.
1880	·20	7·26	1·65	—	22·49	·25	—	—
1881	·99	5·74	5 48	2 01	5·38	1·87	—	·20
1882	1·03	66·9	4·94	2·54	6.26	3·30	·12	·03
1883	·64	10·36	·87	3·43	4 90	1·09	·26	·18
Average ...	·71	7·51	3·24	2·00	9·76	1·63	·09	·10

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* Since this was written I have erected instruments at Mount St. Bernard, 5036-feet elevation, in charge of Mr. Boustead.

Thus the average brought by southerly winds has exceeded that brought by northerly in the proportion 13·4 to 11·4. Arranged according to the seasons, we find the rainfall during spring is nearly double that of summer or winter. The heaviest flood on record occurred towards the close of the autumnal season during May, 1870.

Year.	Autumn.	Winter.	Spring.	Summer.	Year.
1880	9·08	5·52	7·52	7·83	1879-80
1881	5·68	3·74	7·84	4·38	1880-81
1882	5·21	6·80	8·78	2·26	1881-82
1883	3·44	4·64	8·93	4·21	1882-83
Average	5·85	5·19	8·27	4·67	

The probable annual rainfall at Omeo amounts to 25 inches, and the prevailing moisture-laden winds are south-westerly and north-westerly. During exceptional seasons heavy rains come from S. or S.E. Rev. Mr. Veal, of Bright, informs me that the rainy months at Bright, which is N.W. from Omeo in the valley of the Ovens, are June to October, and that the moisture-laden winds are prevailingly north-westerly; that the greatest fall of rain which has been recorded within 24 hours is 4·68 inches. As Bright is situated where the ascensional movements of north-westerly currents of air commence to sweep over the high Bogong Ranges to the east, it is not to be wondered at that the rainfall at this place should be the heaviest for the number of days upon which rain fell throughout the year among the official returns for different parts of the colony, averaging ·40 inches per day.

SNOW.

Snow falls at all heights above 2000 feet, but at the lower levels seldom remains longer than a few days, thawing quickly as it falls, unless on the shaded hill-sides, where the frosts harden the crust. The distribution of snow seems to be affected by many complex causes; it is noticed that at similar elevations, in the same locality, the depth of snow after a fall is very unequal. It is possible that different radiating properties of various soils or rock masses* may exert some influence in the more rapid congelation or thawing of snow-flakes, or that parallel air currents may be of different degrees of moisture or of temperature. It is not unusual after a snowstorm to find at night that the snow which has fallen in the open is more luminous than that which has fallen in the shade of timber trees. This peculiar phosphorescence is no doubt due to exposure during the day of the many reflecting surfaces of the small speculæ of ice to the sun's rays, and to their retaining the light after the sun has set.* The year 1882 was apparently an exceptionally snowy season, both at Omeo and at the higher levels. Mr. Easton, an old resident, informs me that the greatest depth of snow which fell during 24 hours, within his recollection, was a little over a foot in the open at Omeo during July, 1869. On July, 1876, fully 11 inches fell at Omeo during 24 hours; since then the average fall at one time has not exceeded 6 inches. It must be borne in mind, however, that a uniform fall of one foot of snow at a time is very unusual in the British Islands,† and consequently even at 2000 feet elevation at this latitude, 37° south, such a fall would also be unusual. From a calculation of the quantity or depth of snow which fell at Omeo for the period under consideration, we shall find that the mean annual fall does not exceed 2 feet 3 inches, or nearly the same as that at New Jersey in North America. The heaviest fall on record at Grant (according to Mr. Harrison, jun.), which is nearly 2000 feet higher than Omeo, was from 2½ to 3 feet; while Mr. Boustead informs me that the average maximum fall of snow at Mount St. Bernard (5000 feet) measures 14 feet, with 20 to 30 feet in the drifts. I have observed near the summit of Mount Kosciusko, at an elevation of 7200 feet, masses of consolidated snow fully 30 feet deep—maiden glaciers—resting in the hollows of verdant slopes during mid-summer. And as the huge masses of tabular granite which form the rocky crests of this important mountain chain (presenting in many places escarpments fully 40 feet above the gentle slopes which surround them) are covered with snow early in June of each year, it is not improbable that the annual fall at this elevation amounts to 50 feet, corresponding to an annual rainfall of from 50 to 60 inches. I am not aware that there is any rule for increase of fall of snow with elevation. I am inclined to believe that there are vapour planes, and that upon the percentage of moisture present in any of these zones, or the degrees of temperature—which are no doubt governed by many complex causes at present little understood—the fall of snow depends. From the following table of dates upon which snow fell at Omeo it will be seen that June, July, and August are snowy months.

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* Phil. Trans. London, 1847, p. 119.

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* Loomis' Met., p. 126.

† Scott's Met., p. 141.

1879.		
	Min. Temp.	Wind.
June 18	32	S.W.
,, 28	35	,,
July 9	32	,,
,, 10	30	,,
,, 25	33	,,
Aug. 18	33	,,
Total depth of snow	1 ft. 6 in.	

1880.		
	Min. Temp.	Wind.
June 8	31	S.W.
,, 15	40	N.E.
,, 17	33	N.W.
,, 19	27	N.E.
July 1	33	N.W.
,, 2	27	S.W.
,, 19	34	,,
,, 20	34	,,
Aug. 11	34	,,
Total depth of snow	2 ft. 3 in.	

1881.		
	Min. Temp.	Wind.
June 4	37	N.W.
,, 7	31	,,
,, 8	31	,,
,, 19	31	,,
July 15	34	N.
,, 28	33	S.W.
Aug. 23	35	S.
Oct. 4	37	,,
,, 22	35	S.W.
Total depth of snow	2 ft. 3 in.	

1882.		
	Min. Temp.	Wind.
June 1	35	N.
,, 21	29	N.E.
,, 24	38	,,
July 13	36	N.W.
,, 25	36	,,
,, 26	32	,,
,, 28	27	N.
,, 29	29	N.W.
,, 31	33	N.E.
Aug. 13	35	S.
Sept. 1	35	S.W.
,, 7	32	,,
Total depth of snow	3 ft.	

1883.		
	Min. Temp.	Wind.
July 10	30	S.W.
,, 27	32	N.
,, 28	33	,,
Aug. 4	32	S.
Sept. 13	32	S.W.
,, 14	32	S.
Total depth of snow	3 ft.	

1884.		
	Min. Temp.	Wind.
Aug. 18	30	S.W.
,, 19	30	,,
Total depth of snow	1 ft.	

HAIL.

Hailstones, although frequent in the higher regions of the Australian Alps during summer and autumn, are not so at sub-alpine altitudes, although it is somewhat remarkable that the size of the hailstones is frequently much larger at elevations of 2000 to 4000 feet than at higher levels. I have noted hailstones fully half an inch to three-quarters of an inch in diameter,* and during October last some curiouslyshaped masses fell at Dargo, fully half an inch in diameter; some were ovoid, and others not unlike a truncated cone. As a rule, the hailstones come from the westward, and are generally accompanied by electric discharges or strong wind.

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* Fell at Gelantipy during May, 1869.

MOISTURE OF THE ATMOSPHERE.

Unfortunately the hygrometric records do not extend further back than May, 1883, when wet and dry bulb thermometers were supplied me by Mr. Ellery. The following table exhibits the mean temperature of dew-point for each month from May, 1883, to November, 1884, and for the seasons of the year. The results for winter are more complete, being the mean of two years. It will be seen that the lowest mean temperature of the dew-point is reached during the month of July, and highest during February, corresponding in this respect to the temperature of the air :—

December ...	50·58	March	50·39	June	38·04	September	40·51
January ...	52·18	April	48·66	July	36·03	October	45·79
February ...	53·08	May ...	38·33	August	37·93	November	49·95
Mean Summer	51·94	Autumn	45·79	Winter	36·66	Spring ...	45·35

—giving a mean annual temperature of the dew-point of 45·16. During winter months, when the temperature of the air fell below freezing point, I have discarded the results owing to the difficulty of registering the dew-point with the dry and wet bulb thermometers.

I have not given the relative humidity or elastic force of vapour, as it was thought better to defer these until a longer series of observations have been made. It may be interesting to note that the humidity of the air varies greatly during the summer months, especially at the higher elevations; and at the lower levels, as at Omeo, the shifting of the wind from N. to S.W. and S. sometimes causes an excessive humidity, as shown by the dense fogs which frequently envelope the higher points over 4000 feet; during summer a feature connected with such hygrometric conditions are what is locally termed southern fogs.

FOGS.

Often when the sky is clear during the morning towards afternoon dense masses of vapour are seen floating up the valleys of the Tambo and other streams from the seaboard, at a mean elevation of 3000 feet, and settling on the ranges round Omeo, causing a rapid fall of the temperature. These fogs are, according to the old residents, generally the forerunners of dry seasons, and are altogether distinct from the ordinary radiation fogs of Sir M. Herschel.* Last Christmas, while botanising on Mount Kosciusko, an opportunity was afforded the writer of watching the progress of one of these southern fogs coming from the seaboard. A warm cloudless morning, with the thermometer 92 in the sun, at an elevation of 7000 feet at one p.m., was followed by a warm cloudless afternoon; until five p.m. large masses of what appeared to be dense nimbus clouds were seen on the southern horizon; these gradually enlarged, and could be seen surging up the valleys. At last the temperature sank to 43° Fahr., when a dense fog suddenly enveloped the summit of the mountain, and in a few minutes began to clear off again, sinking to a level of about 6000 feet, and there remained like a wide expanse of silvery ocean during the clear moonlight night, until dissipated by the warm golden rays of the rising sun. A peculiar feature of such fogs is that the upper part is cooler than the lower—*i.e.*, when the fog-masses are rising radiation of heat is greater at the upper than at the lower part.

CLOUDS.

The following table shows the mean or average number of days upon which the sky was overcast, cloudy, and clear at nine a.m. for each month of the year. These results are obtained from the daily observations between 1st April, 1879, and 1st November, 1884:—

Months.	O'cast.	Cloudy.	Clear.	Months.	O'cast.	Cloudy.	Clear.
January ..	3	14·6	13·4	August	5·3	14·2	11·5
February ..	2·8	13	12·2	September ..	9	11·7	10·1
March	4·8	16·6	9·6	October.. ..	4	16·8	10·2
April	5	17·5	7·5	November ..	3·5	16·3	10·2
May	5	17·3	8·9	December ..	3	16·8	9·2
June	3·4	16·3	10·3				
July	7	13·7	10·3	Yearly Average	55·8	184·8	123·4

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* Scott's Meteorology, p. 121.

SEASONS.

	SPRING.			SUMMER.			AUTUMN.			WINTER.		
	O'cast	Cldy.	Clear.	O'cast	Cldy.	Clear.	O'cast	Cldy.	Clear.	O'cast	Cldy.	Clear.
Mean..	14·8	51·4	26·0	8·8	44·4	44·8	16·5	44·8	30·5	15·7	44·2	32·1

It will be observed, that although the number of cloudy days is in excess of the clear for the entire year, yet the latter more than double those upon which the sky was overcast. It is also noticeable that the number of clear days is greater during summer and winter than in the spring or autumn. The beautifully clear cool days of winter are a noticeable feature in the climate of the Australian Alps, although frequently preceded by hard frosts and occasionally followed by heavy snow falls.

FROSTS.

As the time of year in which frosts occur has an important influence on the success or otherwise of agricultural operations, it becomes interesting to note how often they have been found to take place within the period herein discussed. The following table gives the number of days during each month since 1879 upon which they have occurred :—

1879.	1880.	1881.	1882.	1883.	1884.
Days. June .. 5 July .. 4 Aug. .. 6	Days. June .. 5 July .. 8 Aug. .. 1 Sept. .. 2	Days. May .. 4 June .. 5 July .. 3 Aug. .. 2	Days. May .. 2 June .. 2 July ..10 Aug. .. 3 Sept. .. 1	Days. May .. 2 June .. 6 July .. 6 Aug. .. 4 Sept. .. 1	Days. May .. 4 June .. 6 July ..12 Aug. .. 3 Sept. .. 1
Total No. of days for year 15	16	14	18	19	26

Mean No. of days per month—May, 2 ; June, 4·8 ; July, 7·2 ; August, 3·2 ; September, ·83.

It will be seen by the above that the present year has been unusually frosty, and ranged from May to 18th September. As the seasons are later at sub-alpine habitats above 2000 feet, the September frosts, which might prove injurious in the lowlands, are not so much so at these elevations. The month of July is noted for severe and successive hard frosts, the minimum temperature during such frosts ranging from 32° to 19° Fahr. It is possible that the occurrence during September of occasionally severe frosts has led to the statements of the early pastoral settlers as to the uncertainty of cereal growths. These facts serve to support the opinion of the Surveyor-General and late Secretary for Mines, as quoted at the commencement of this paper. It is only in the valleys that the severest frosts take place. I have observed lowland exotic plants flourishing on the ridges which perished under extreme frost in the valleys, the temperature being more equable at the former habitat than in the latter.

TEMPERATURE.

The range of temperature at sub-alpine elevations is apparently large, while the rapidity of the changes increases with the elevation (see remarks on Climate at 5000 feet, p. 141). The mean annual temperature deduced from the following table gives 53° 34′, almost the same as at Ballarat,[*] although there is probably a greater absolute range of annual temperature at Omeo than at the former place. The highest recorded temperature in the shade at Omeo for the period herein discussed occurred on the 21st January, 1880, when the maximum thermometer registered 105° at 1.30 p.m.; and the lowest in July, 1883, at 6.10 a.m.—the occasion of a severe frost, when the minimum thermometer registered 19° Fahr., or 13° below freezing point—or an absolute range of 128°, nearly as large as Chicago, Illinois, America.[†]

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[*] Exhib. Essays, p. 5.

[†] Loomis' Met., p. 272.

TABLE *showing maximum, minimum, range, and mean monthly temperature in the shade, from April,* 1879, *to November*, 1884, *at Omeo.*

MONTHS.		1879.				1880.				1881.				1882.				1883.				1884.			
		Max.	Min.	Rge.	Mean	Max.	Min.	Rge.	Mean	Max.	Min.	Rge.	Mean	Max.	Min.	Rge.	Mean	Max.	Min.	Rge.	Mean	Max.	Min.	R ge.	Mean
Summer	December ..	...	...	...	...	76·1	44 0	32·1	60·04	81·0	49 0	32·0	65 0	...	47·5	...	...	77·0	47·1	29·9	62·6	...	...	...	...
	January ...	...	...	...	...	88·5	47·1	41·4	67 8	87·5	47·7	39 8	67·6	85·0	50 0	35 0	67·6	...	49·7	...	...	78·5	44·4	34·1	61·4
	February ...	...	...	...	...	83 3	50·5	32·8	66·9	87·8	48·0	39·8	67 9	83·8	49·4	34·4	66·6	...	52·7	...	...	78·5	49·4	29·1	63·9
	Mean temp. for season	...	...	...	...	82·6	47·2	35·4	65·0	85·4	46·5	37·2	66·8	84·4?	48 9	...	67·1?	...	49·8	..	62·6?	...	...	...	62·6?
Autumn	March ...	...	...	...	...	70 2	50·4	19 8	60·3	80·1	47 6	32·5	63 9	77·8	44 3	33·5	61·0	...	53·7	...	...	77·5	38·6	38 9	57·6
	April ...	73 7	39·3	34·4	56·5	66·9	44·9	22·0	55·9	73·1	39·2	33·9	56·2	...	37·9	...	...	...	51·8	...	...	68·0	47·4	20·6	57·7
	May ...	56·2	38·1	48·1	47·2	53·2	37·2	16 1	45·2	67·3	39·1	28·2	53·2	...	37 9	...	...	57·8	35 8	22·0	46 8	55·2	35·4	19·8	42·2
	Mean temp. for season	...	...	...	51 8?	63·1	44·1	19·3	53·8	73·5	41 9	31·5	57·7	...	40·0	...	...	...	47·1	...	...	66·9	40 9	26 4	52 5
Winter	June ...	49·7	32·4	17·3	40·7	51·0	33 0	18·0	42·0	56·2	32·9	23·3	49·5	...	32 4	...	...	53·2	35·4	17·8	44·3	53·3	33·5	19·8	43 4
	July ...	51·7	26 9	24·8	39·3	50·1	30·1	20·0	40·1	55·7	31·2	24·5	43 4	...	32·6	...	...	50 0	31·7	18·3	40 9	52·4	26·0	26 4	39 2
	August ...	53·7	34·8	18·9	44 2	56·5	32·2	24·3	49·9	58 2	35·2	23 0	46 6	...	34 3	...	...	56·2	33·4	22·8	49·8	60·1	32·2	27·9	46·5
	Mean temp. for season	51·7	31·3	20·3	41·4	52·5	31·7	20·7	44·0	56·7	33·1	23·6	46·5	...	33 1	...	...	53·1	33·5	19·6	45·0	55·2	30·5	24·3	43 0
Spring	September ...	61·2	38·9	22·3	50·1	65 0	35·8	29·2	50·4	63·8	36·8	27·0	50·3	...	37·9	...	...	55·7	36 2	19·5	45·9	64·5	35·4	29 1	49 9
	October ...	65·7	42.2	23·5	53·9	72·3	36·8	35·5	54·5	66·2	41·0	25·2	53·6	...	41·0	...	...	60·8	41 0	19 8	50 3	...	...	...	...
	November ...	70·3	41·8	28·5	56·1	79 9	42·5	37·4	61·1	74·5	43·8	30·7	59·2	...	45·1	...	...	65·7	43·5	22·2	54·6	...	...	...	...
	Mean temp. for season	65·7	40·9	24·7	53·3	72·4	38·3	34·1	55·3	68·1	40·5	27·6	54·3	...	41·3	...	...	60·7	40·2	20·5	50·2	...	...	...	...

From this table the following mean monthly temperatures are obtained :—

January	66·10	August	47·07
February	66·07	September	49·26
March	60·70	October	53·07
April	56·28	November	57·75
May...	46·92	December	62·03
June	43·92		
July...	40·58	Mean annual temp.	53·34

And also the mean temperature for the seasons, as follow :—

Spring, 53 ; Summer, 64 ; Autumn, 54 ; Winter, 43.

The variation to which the law of decrease of temperature with elevation is subject is well shown by many localities in the Australian Alps, particularly by the presence of many tropic types of vegetation in the humid soils on the most southern slopes, at elevations of 3000 feet ; and the mean temperature is probably greater—at similar elevations—on the northern sunny slopes than on the moist southern slopes ; and the absolute range of temperature is also greater on the former than on the latter at similar elevations. Again, those localities open to the cooling influence of polar winds would, doubtless, show a lower mean annual temperature than those localities on the same latitude, at the same elevation, although exposed to the warming influence of equatorial winds.

The following table gives the mean monthly temperature of the surface of the ground at 9 a.m., and also that for the seasons :—

Summer.		Autumn.		Winter.		Spring.	
December..	79·52	March ..	70·93	June ..	46·43	September	57·27
January ..	79·60	April ..	66·00	July ..	45·41	October ..	65·04
February ..	81·82	May ..	49·56	August ..	55·37	November..	70·00
Mean temp.	80·45	Mean temp.	62·16	Mean temp.	49·07	Mean temp.	64·10

This gives a mean annual surface temperature in the sun of 63° 88′, or a little over 10 degrees higher than the mean annual temperature of the air in the shade, four feet from the ground. This large mean annual surface temperature must necessarily affect the amount of spontaneous evaporation at Omeo.

The atmometric records are only available from October, 1883, to November of the present year; and the resulting figures are therefore an approximation only, yet sufficient, I think, to indicate that spontaneous evaporation is in excess of rainfall at Omeo. A noticeable instance of evaporation over a large surface is furnished by Lake Omeo, which in 1882 was a sheet of water 2 miles long by 1 mile broad, and with an average depth of probably 2 feet 6 inches, or less. This lake became dry during the present year, and this accords with the following approximate results from the evapometer at Omeo, *e.g.*, 30½ inches per annum. It must be borne in mind, however, that the evaporation from a sheet of water freely exposed to the accelerating influence of summer winds, would be greater than that from a situation sheltered by high ranges. It is a remarkable fact that during seasons of severe frosts many small creeks and water channels become dried up thereby.

December ..	3·56	March ..	2·80	June ..	·50	September ..	2·50
January ..	5·50	April ..	1·10	July ..	·30	October ..	4·28
February ..	4·68	May ..	·80	August ..	·75	November ..	3·75
Total for season	13·74		4·70		1·55		10·53

WINDS.

The following table exhibits the average number of days the wind blew from the different points of the compass, and the mean velocity in miles per hour for each month of the year, and the mean velocity for each point for different seasons :—

MONTHS.		N.		N.E.		N.W.		S.		S.E.		S.W.		E.		W.		Mean velocity of wind per month per hour.
		Mean No. of days.	Mean velocity per hour	Mean No. of days.	Mean velocity per hour	Mean No. of days.	Mean velocity per hour	Mean Mo. of days.	Mean velocity per hour	Mean No. of days.	Mean velocity per hour	Mean No. of days.	Mean velocity per hour	Mean No. of days.	Mean velocity per hour	Mean No. of days.	Mean velocity per hour	
Summer	December	2·7	11	5·4	14	2·2	15	3	8	2	9	4	11	3	10	..	..	11·1
	January	3·7	15	5·5	8	2·7	17	3·7	9	2·6	11	4·8	10	2	8	1·5	10	11
	February	2	8	5	9	2	8	4	12	2	8	2·7	11	2	9	..	..	9·3
		8·4	11·4	15·9	10·3	6·9	13·3	10·7	9·6	6·6	9·3	11·5	11	7	9	1·5	10	10·5
Autumn	March	2·3	9	4·6	8	1·5	8	1	8	1	9	2·7	10	1·5	11	..	..	9
	April	2·5	10	6·0	12	2·6	13	1·5	10	2	15	4·6	8	1	8	..	..	10·9
	May	2·3	8	3·7	9	6·7	10	1·5	8	3	8	4·3	10	2	13	..	..	9·4
		7·1	9	14·3	9·6	10·8	10·3	4	9	6	10·6	11·6	9·3	4·5	10·6	..	..	9·7
Winter	June	4	9	7	10	4·6	14	1·3	9	..	..	2·5	8	2	8	1	8	9·5
	July	3	10	5·5	10	5·2	8	1	8	1	8	3·6	9	2	8	1	8	8·7
	August	3·6	10	7·5	19	3	9	3	8	2	8	2·5	10	2	9	..	..	10·4
		10·6	9·6	20	12·9	12·8	10·3	5·3	8·3	3	8	8·6	9	6	8·3	2	8	9·5
Spring	September	5·5	9	7	9	3·6	12	2	12	2·6	10	2·5	9	1·5	9	1	8	9·7
	October	4·5	10	6·5	8	2	14	1·6	8	2·6	8	3	11	3·5	8	..	..	11·1
	November	1	8	7·7	8	4·3	11	3	10	3·7	8	5·2	10	..	..	..	..	9·1
		11	9	21·2	8·3	9·9	12·3	6·6	10	9	8·6	10·7	10	5	8·5	1	8	10·1
		..	9·3	..	10·2	..	11·5	..	9·2	..	9·1	..	9·8	..	9·1	..	8·6	9·95

The number of times which the wind blew from the N.E. being greatly in excess of that from any other cardinal point, may be partly accounted for by the trend of the Livingstone Creek Valley and the Dividing Range to the east deflecting the north and north-north-westerly currents of air. The relatively small velocities are also probably owing to the somewhat sheltered position of the observatory, partly surrounded by high ranges, which intercept the strong N.W. to S.W. winds. The greatest mean velocity of the wind occurs during spring and summer, and principally with north-westerly currents of air. The greatest velocity recorded at Omeo with a cup anemometer was forty-eight miles per hour during a strong gale from the N.N.W. Anemometrical records from Mount Hotham would show interesting results, as the strong westerly gales which flow at this elevation are a noticeable feature during the equinoctial season. On the whole, westerly winds may be said to predominate in the Australian Alps, although local influences at lower sub-alpine altitudes cause deflection and obstruction to aërial currents, as shown by the results at Omeo, where the prevailing winds are northerly. A remarkable phenomenon connected with the temperature of wind which has been frequently noticed in the sub-alpine valleys of the Australian Alps is the occasional whiffs, during frosty mornings, of warm currents of air, producing an irritation of the throat and nose similar to that felt when ozone is largely present in the atmosphere. How far these peculiar abnormal air-movements are due to electrical agencies, or to the actual presence of isolated masses of warm dry air, which have come to us from the heated interior of Australia, I am unable to suggest; I simply note the fact as one which requires some explanation. Owing to the situation of Omeo with reference to the higher regions of the Australian Alps, hot winds are comparatively unknown; the N.N.W. and N.W. hot winds, during summer, come down to us cooled by their passage over the Bogong High Plains.

PRESSURE OF THE ATMOSPHERE.

The maximum of mean monthly pressure of the atmosphere occurs during August, while the greatest absolute pressure for the period during which observations were taken occurred on 30th July, 1883, when the reading of the barometer, reduced to sea level and temperature 32° Fahr., gave 30·280. The lowest reading of the barometer, reduced to sea level and 32° Fahr., took place on 28th December, 1881, viz., 29·600, with squalls from N. followed by a thunderstorm. As a rule the barometer at Omeo stands lower with the winds from N.N.E. to N.N.W., and higher from S.S.W. to S.E., although frequent departures from this rule occur.

Summer		Autumn		Winter		Spring	
Dec. ..	30·040	March	30·120	June ..	30·136	Sept...	30·070
Jan. ..	29·683	April	30·153	July ..	30·210	Oct. ..	30·090
Feb. ..	30·053	May ..	30·113	Aug. ..	30·266	Nov. ..	29·920
Mean Summer ..	29·925	Mean Autumn	30·128	Mean Winter ..	30·214	Mean Spring	30·126

The mean pressure during winter is greatest, and during summer least.

The following table shows the mean range in pressure for the different months, and also that for the seasons :—

December ..	·656	March ..	·610	June	·860	September ..	·825
January ..	·616	April	·506	July	·826	October ..	·595
February ..	·685	May	·953	August ..	·826	November ..	·746
Mean Season	·645	Mean Season	·689	Mean Season	·837	Mean Spring	·722

This gives a mean monthly range for the year of ·717. The rule for decrease of pressure with altitude would seem to be subject to slight variations caused by lateral pressures, aërial currents sweeping up the narrow valleys, and by thermal influences of a local character, so that the difference of surface configurations and surroundings of two stations on the same parallels of latitude, and at the same altitude, may differ slightly in their barometric pressures.

The following records, kindly supplied by Mr. William Boustead of Mount St. Bernard, are very interesting, as showing the character of the climate in the higher regions of Victoria during winter. Unfortunately no records of maximum or minimum temperatures are available, although the ten a.m. observations of thermometer in the shade are extremely valuable. From this and other data, collected when travelling over different parts of the Alps, the following abstract of the climate at elevations of 5000 to 6000 feet is obtained. The mean winter temperature at Mount St.

Bernard, 5060 feet, would appear to be 33·91 Fahr., or about two degrees above freezing point. The lowest temperature recorded from ten a.m. observations is 29°, and the maximum 70° in the shade, 90° in the sun. July and August are the coldest months, February and March the warmest. The seasons of maximum cold for the past thirteen years appear to have been 1876, 1881, and 1882; and the season of greatest heat, 1882. The fall of snow sometimes commences as early as April—although May is the usual month—and begins to disappear during September, sometimes October. April is frequently a rainy month, and during January and February thunderstorms are prevalent, invariably from the westward. As a rule the prevailing winds are from—

S.W. to N.W.	during	summer.
S.W to S.E.	„	autumn.
N.W.	„	winter.
W. to N.W.	„	spring.

The wind blows with great force at these elevations, and the changes are very rapid. Mr. Boustead informs me that he has had thick fogs with rain all day at Mount St. Bernard, while three miles lower down, or at an elevation of 4000 feet, the sun has been shining in a clear sky! He also remarks that it is an unusual thing to have a Christmas without snow.

WEATHER *observations made at Mt. St. Bernard*, 5060 *ft. above sea-level, during winter months, June, July, & Aug.*, 1882.

Date.	Therm. in shade.	JUNE. Remarks.	Therm. in shade.	JULY. Remarks.	Therm. in shade.	AUGUST. Remarks.
1	...	...	31	Hard frost, and strong N.W. gales	30	Snow and thick fogs all day
2	...	...	31	,, ,,	30	N.W. winds, con. snow
3	...	...	32	,, ,, clear	32	Strong N.W. winds, con. snow
4	...	...	32	N.W. gales and fogs	30	Thick fogs, ,,
5	...	...	34	,, ,,	30	Snowing all day
6	...	...	36	Strong wind with rain	32	Snow in morng., fine aftern.
7	...	...	35	Strong N.W. wind with showers	32	Clear light winds, snow in aft.
8	...	...	38	Moderate N.W. winds, thick fogs	30	Lt. N.W. winds, slight snow
9	..	...	35	Light winds and snow	32	Clear, latter part cloudy
10	...	...	32	Str. N.W. gales, hard frost, snow	32	Hard frost, con. fair weather
11	...	...	30	Frost, fogs, snow, and heavy gales	32	,, light winds, snow
12	...	...	30	Frost, fogs, and snow	32	,, ,,
13	38	Moderate S.E. winds with snow	30	,, and continued snow	34	Fine and clear all day
14	34	Strong N. to N.W. winds with heavy snow	30	,, and light N.W. winds	36	Light N.W. winds, fine & clear
15	32	Continued snow	30	,, ,,	34	Hard frosts, ,,
16	32	N.W. winds and snow	30	Strong S.E. winds and frost	32	Strong N.W. gales, with snow
17	34	Continued snow	32	Moderate S.E. winds and fine	32	,, sleet and rain
18	34	N.W. winds and snow	32	Frosts, fine and clear	34	Mod. N.W. winds, thick fogs
19	34	Light N.W. winds and snow	35	,, ,, noon	36	Frosts, fine and clear
20	35	Light winds with snow	35	,, ,,	48	N.W. winds, fine and clear
21	38	Fine clear weather	35	N.W. winds, fine weather	42	Light winds, rain, cloudy
22	38	,, ,,	38	Frosts, light winds, clear	44	,, thick fogs
23	36	,, ,,	36	Frosts, strong winds, cloudy	46	Fine and clear all day
24	30	Strong N.W. gales, hard frost, thick fogs	34	N.W. gales, hail and snow	46	,, ,,
25	36	Moderate and clear	32	Strong N.W. winds, snow and fogs	46	Strong winds, thick fogs
26	36	Fresh S.E. winds and fine, fogs in evening	30	Heavy snows and fogs	46	,, ,, rain
27	34	Fine weather	32	Light N.W. winds, snow showers	46	Raining all day, sn. thawing
28	34	Strong winds and thick fogs	30	,, ,, frosts	46	Light rain, thick fogs
29	32	Hard frost, heavy gales and fogs	30	Frost, light N.W. winds, clear	44	Strong N.W. winds, thick fogs
30	30	Strong winds, moderate towards night	30	Strong N.W. winds, snow and frost	42	Rain and snow all day
31			30	Cloudy, and snowing all day	40	Strong N.W. gales, with snow
Means	34·27		32·48		37·03	

WEATHER *observations made at Mt. St. Bernard*, 5060 *ft. above sea-level, during winter months, June, July, & Aug.*, 1883.

Date.	Therm. in shade.	JUNE. Remarks.	Therm. in shade.	JULY. Remarks.	Therm. in shade.	AUGUST. Remarks.
1	32	Moderate N.W. winds with sleet	36	Strong N.W. gales, rain and fogs	40	Con. fine clear weather.
2	30	Thick fogs, rain, and sleet	36	,, thick fogs, rain	42	S.W. winds ,,
3	32	,, N.W. wind, light snow	36	Thick fogs, mod. and fine in evening	42	Light N.W. winds, light frosts
4	34	Moderate N.W. winds, fair weather	38	Moderate S.W. winds, clear weather	38	Light W. winds, rain, snow
5	36	,, S.E. ,, thick fogs	38	Moderate N.W. winds, ,,	36	Strong W. winds, snow, fogs
6	36	,, ,, ,, clear weather	38	,, heavy fogs	32	Cloudy cold weather all day
7	40	Light S. winds, thick fogs	34	,, fogs, snow, rain	32	Strong N.W. winds, cloudy
8	38	Moderate S.E. winds, clear weather	32	Strong N.W. gales, snow, fogs, frost	34	Light N.W. winds, dense fogs
9	40	Fine and clear all day	32	Strong W. gales, with snow	34	Strong W. ,, ,,
10	40	Light N.W. winds, and fine weather	30	Dense fogs, snowing heavily	34	,, N.W. gales, cloudy
11	44	,, ,,	30	Strong W. gales, sleet and snow	38	,, ,, heavy snow, cold
12	44	,, thick fogs, cloudy	30	Str. N.W. gales, dense fogs, rain, sleet	38	,, ,, snowing heavily
13	40	N.W. winds, overcast, cloudy	32	,, snow and sleet	36	,, ,, with snow
14	40	Strong N.W. winds, thick fogs, sleet	34	,, thick fogs	36	,, ,, ,, heavy fogs
15	38	,, dense fogs, heavy rain	32	,, ,, very cold	36	,, ,, ,, ,,
16	38	,, ,, ,,	32	Hard frosts, snow, dense fogs, ,,	36	,, ,, heavy fogs, frosts
17	38	Thick foggy weather	30	W. wind, hard frosts, clear	36	Heavy N.W. gales, thick fogs, rain
18	36	N.W. winds, heavy fogs	30	S.W. winds, cloudy, severe frosts	36	Heavy rains, W. gales
19	36	Moderate N.W. winds, heavy fogs	34	Light S. wind, snow, hard frosts	36	,, ,,
20	38	Heavy fogs, rain in evening	36	Fine and clear all day ,,	34	Strong N.W. gales, snow, fogs
21	36	Light N.W. winds, heavy fogs	36	,, ,,	38	Light S.W. winds, hard frosts
22	36	Strong N.W. gales, heavy rains	36	Cloudy weather, light snow	38	Strong ,, ,,
23	36	,, sleet, rain, fogs	38	Fine and clear all day, hard frosts	38	,, ,, fine weather
24	34	,, snow, frosts, fogs	36	,, N.W. wind ,,	38	,, ,, ,,
25	34	N.W. wind, sleet, and heavy fogs	36	Light N.W. winds, ,,	32	Light N.W. winds, cloudy
26	34	N.W. wind, dense fogs, sleet and rain	34	Strong W. ,, snow, frosts	32	Strong N.W. gales, very cold
27	34	Strong N.W. gales, fogs, hail and rain	30	,, ,, snowing, very cold	36	,, ,,
28	36	,, dense fogs, light rain	30	Moderate N.W. winds, snowing	36	,, clear weather
29	36	N.W. winds, dense fogs	32	S.W. winds, clear weather	36	Light N.W. winds ,,
30	34	Str. N.W. winds, dense fogs, light rain	34	W. wind, and fine snow	36	,, and snow
31			38	S.W. wind, and fine weather	36	,, ,,
Means	36·66		33·83		35·22	

In addition to the various meteorological elements herein referred to, the amount of direct sunshine and percentage of ozone in the atmosphere is now observed at Omeo, but as the period of observation does not extend beyond July of present year the results are not given. It may be remarked, however, that the ozone reaction seems to be greatest with winds from the south, and least with northerly winds, although further more extended observations may modify this result. In respect to the sunshine recorder, I may state that from a number experiments made with a view to obtain an inexpensive instrument, I have found that a blown glass sphere filled with water, and with a glass tube bent like a syphon, to allow for expansion of the water during great heat, acts admirably; the heat rays passing through the vessel, without much interference, burning a line on the prepared paper at the true focal length. The only difficulty in using this instrument is the rapid expansion due to the reduced temperature—*i.e.*, when the water freezes in the sphere in cold weather; but as the temperature during the day never sinks below the freezing-point—*i.e.*, when the sun is shining—this difficulty is obviated by removing the instrument, which is on a movable stand, inside at night. Various other forms of meteorological phenomena—such as optical, electrical, &c.—remain to be discussed; but as these have not, so far as I am aware, any direct influence in estimating the probable climatology of a district, I have not thought it necessary to furnish any particulars of records taken of the former in the present paper.

TRACES OF A FORMER GLACIAL PERIOD IN THE AUSTRALIAN ALPS.

In concluding the present introduction to the Meteorology of the Australian Alps, I have great pleasure in reporting what may, I think, be considered as conclusive evidence of the existence of a glacial period in the Australian Alps during Post-miocene Times. The able arguments set forth by Mr. Griffiths, in his "Evidences of a Glacial Period in Victoria during Post-miocene Times," read before this Society on 19th March last, led me to examine carefully the surroundings of the Dry Gully and Lake Omeo areas, with the results that I have been fortunate enough to discover undoubted evidences of glacial action. Distinct rock striæ on hard filsitic and porphyritic rocks at Omeo Plains; on the gneissose rocks, Livingstone Creek, near Omeo; groovings and markings on the bottom of the old lake bed at Dry Gully; numerous erratic and ice-worn boulders, both on the margin of Omeo Plains, and in the Dry Gully, and Livingstone Creek gold workings, which indicate translocating agencies distinct from ordinary fluvial action; as well as other interesting relics, all pointing to a period of great refrigeration culminating in an ice-covered region. I have to thank Mr. Griffiths for the incentive to examine with greater circumspection the geological features of the area with which I thought I had been previously familiar, with the result that I am able to confirm his splendid theoretical deductions by an appeal to actual facts capable of direct verification on the ground. I have been careful not to confound these rock striæ with the slickensides so frequent in faulted geological districts, which would be produced by the downward slidings and crushings of great rock masses during times of volcanic activities. The situation and character of these glaciated rock surfaces are distinctive, and can hardly be mistaken for slickensides. The whole of the proofs which I have to offer in support of Mr. Griffiths' hypothesis, from geological and botanical data, will, I trust, form the subject-matter for a subsequent paper. In the meantime it is hoped that the announcement of the discovery of geological evidences of glaciation in the Australian Alps may not be without interest, and direct attention to the question of pre-existing meteorological changes, suggesting thoughtful inquiry as to the great cosmic causes which have slowly but surely dominated in the evolution of existing climatic conditions from the cycling meteorological changes of past time.*

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* Since the above was written Dr. von Lendenfeld reports the discovery of evidences of glacial action on Mount Kosciusko, *vide* telegram in *Argus* newspaper of January 16th, 1885.